RESEARCH DEPARTMENT

A COMPARISON OF C.W. INTERFERENCE EFFECTS ON COLOUR AND MONOCHROME TELEVISION TRANSMISSIONS

Report No. T-061

(1956/21)

A.V. Lord, B.Sc., A.M.I.E.E.
G.F. Newell, A.M.I.E.E.

W. Proctor Wilson

(W. Proctor Wilson)

Report No. T-061

A COMPARISON OF C.W. INTERFERENCE EFFECTS ON COLOUR AND MONOCHROME TELEVISION TRANSMISSIONS

June 1956

Report No. T-061

(1956/21)

A COMPARISON OF C.W. INTERFERENCE EFFECTS ON COLOUR AND MONOCHROME TELEVISION TRANSMISSIONS

SUMMARY

This report describes measurements of the interference by an unmodulated carrier with both colour and monochrome television reception. The British 405-line system was used for both colour and monochrome transmissions, the colour system being a modified N.T.S.C. type. The results show that colour transmissions are more susceptible than monochrome transmissions to c.w. interference in the region of the chrominance subcarrier because of the additional beat frequency produced.

1. INTRODUCTION.

One of the factors influencing the choice of a colour television system for public service is the susceptibility of the signal to c.w. interference. A colour system of particular interest is the N.T.S.C. system wherein additional colour information is transmitted by the use of a subcarrier located within the band of the equivalent black-and-white system. Such a system, which transmits additional information within the same pass-band, must necessarily be more susceptible to interference in some regions at least of the required transmission band. The effects of the interference upon the reproduced picture will be dependent upon:

a. the amplitude of the interference relative to that of the wanted signal,

b. the frequency difference between the two signals.

The first of these parameters may be expressed as a protection ratio resulting in a defined degradation of the reproduced picture. Results have been published[1] concerning the effect of an interfering c.w. signal upon an N.T.S.C.-type transmission conforming to American standards. These particular results show the differences in protection ratios required for a colour service as compared with those required for the equivalent monochrome service. Tests carried out in this country to date have been limited to the investigation of c.w. interference effects on the normal 405-line monochrome transmission. These results[2, 3, 4] have been obtained in terms of two different criteria; the first being that of "just perceptible" interference as observed under first class receiving conditions, the second refers to practical protection ratios for not more than 10% of the time under fringe area conditions. The purpose of this report is to supply tentative additional information concerning the changes in protection ratios required should a colour system of the N.T.S.C. type be adopted for use within existing monochrome channels. In view of the limited time available the results reported herein are restricted to the subjective criterion

"just perceptible", all the experiments being carried out under first grade receiving conditions. An attempt will be made to assess the results obtained in terms of the more practicable, but experimentally more difficult, criterion of "tolerable for 10% of the time under fringe area conditions".

2. EXPERIMENTAL PROCEDURE.

The tests consisted of measuring the relative amplitudes of a television signal and an "interfering" carrier when the latter was judged to be "just perceptible" on the received picture. Four experimental colour television receivers and two monochrome receivers were used. The interfering carrier was unmodulated and tuned to various frequencies in the bandwidth occupied by the "wanted" signal; at each nominal frequency setting the exact frequency was adjusted over a range of ± 5 kc/s so as to produce the most obvious interference pattern on the viewed picture. The "wanted" carrier was modulated with a complete N.T.S.C.-type waveform, the received picture consisting of electronically generated colour bars. No significant changes were observed in the results obtained when some tests were repeated using colour pictures from a slide scanner. The monochrome transmission used for test was obtained by removing the "burst" and chrominance signals. Four conditions of reception were tested, namely:

a. A colour transmission with a colour receiver.

b. A colour transmission with a monochrome receiver.

c. A monochrome transmission with a colour receiver.

d. A monochrome transmission with a monochrome receiver.

The "wanted" signal which was on a carrier frequency of 45·05 Mc/s had, for peak white modulation, a magnitude of 5·0 mV r.m.s. open-circuit voltage from a source impedance of nominally 75 Ω. The accompanying sound carrier on a frequency of 41·5 Mc/s had a magnitude of 2·5 mV r.m.s. open circuit, and was modulated with tone to a depth of 40%. For a protection ratio of 0 dB the magnitude of the interfering signal was 5 mV r.m.s. open circuit.

Four experienced observers made individual assessments of the interference when viewing at distances ranging from four to six times picture height and the results given in the next section are the averages for all four observers. The receiver under test was tuned to the wanted signal in the absence of interference which, at a nominal frequency of 45·5 Mc/s, was then adjusted to produce an obvious pattern. The amplitude of the interfering carrier was slowly reduced until the pattern was judged to be "just perceptible" by the observer. Having noted the amplitude for each observer, the test was repeated with the interfering carrier at various frequencies down to 41·2 Mc/s.

The receivers used in these tests were:

1. A domestic colour receiver (A) produced by the B.B.C. Research Department. This receiver includes a 21 in. (53 cm) shadow-mask display tube and has a

wide-band chrominance channel, synchronous detection along the I and Q axes being employed.

2. A domestic colour receiver (B) produced by a British radio manufacturer. This receiver also uses a 21 in. (53 cm) shadow-mask display tube and has a wide-band chrominance channel with synchronous detection along the I and Q axes.

3. A domestic colour receiver (C) produced by a British radio manufacturer. This receiver which also uses a 21 in. (53 cm) shadow-mask display tube has a narrow-band chrominance channel. Synchronous detection is performed along the R-Y, B-Y and G-Y axes.

4. A laboratory colour receiver using three 17 in. (43 cm) tubes in a trinoscope display. This produces the equivalent of a 14 in. (36 cm) diagonal picture. The receiver has a fully compensated wide-band chrominance channel employing synchronous detection along the I and Q axes.

5. A laboratory monochrome receiver with a 14 in. (36 cm) display unit.

6. A 21 in. (53 cm) domestic monochrome receiver produced by a British radio manufacturer.

All the receivers were designed for asymmetric sideband reception, using the lower sideband.

3. RESULTS.

As mentioned previously all the observations were based upon the subjective criterion of "just perceptible" and the results obtained are illustrated in Figs. 1 and 2. The first of these shows the protection ratios as a function of the frequency difference between the interfering signal and the vision carrier of an N.T.S.C.-type colour transmission.

It will be observed that there is a considerable degree of similarity in the results obtained for all receivers, indicating that the most significant factors affecting the results are those due to the characteristics of the transmission itself. As might be expected in the case of the colour receivers, the presence of an interfering signal in the region of the subcarrier leads to the production of low-frequency patterns corresponding to variations of hue and saturation. For the monochrome receivers the equivalent effect is one of brightness changes only. From the results obtained it would appear that the low-frequency brightness variations observed on the monochrome receivers are as perceptible as the low-frequency variations of hue and saturation seen on the colour receivers.

A point of minor interest in Fig. 1 is shown in curve (3) where the use of a narrow-band chrominance-channel in receiver (C) has led to a reduction of the required protection against mid-band interference.

Fig. 2 illustrates the results obtained when the wanted transmission conforms to standard monochrome practice. Once again there is general agreement in

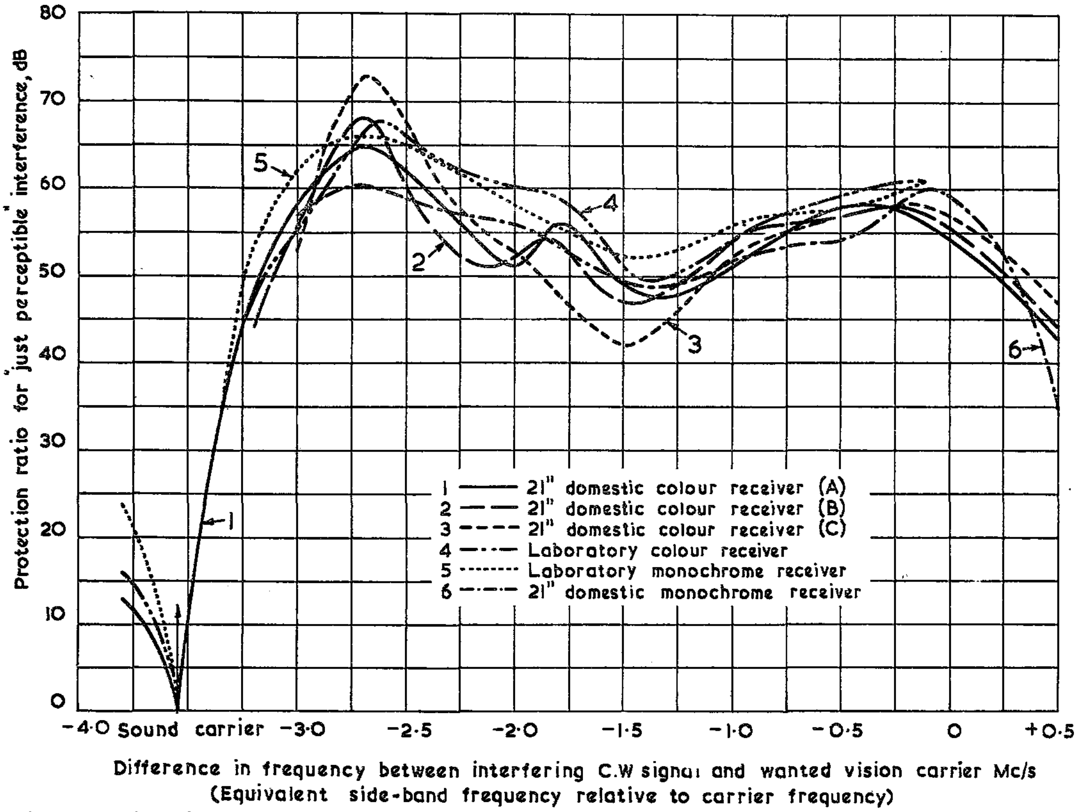

Fig. 1 - Protection ratios for colour transmission to colour and monochrome receivers

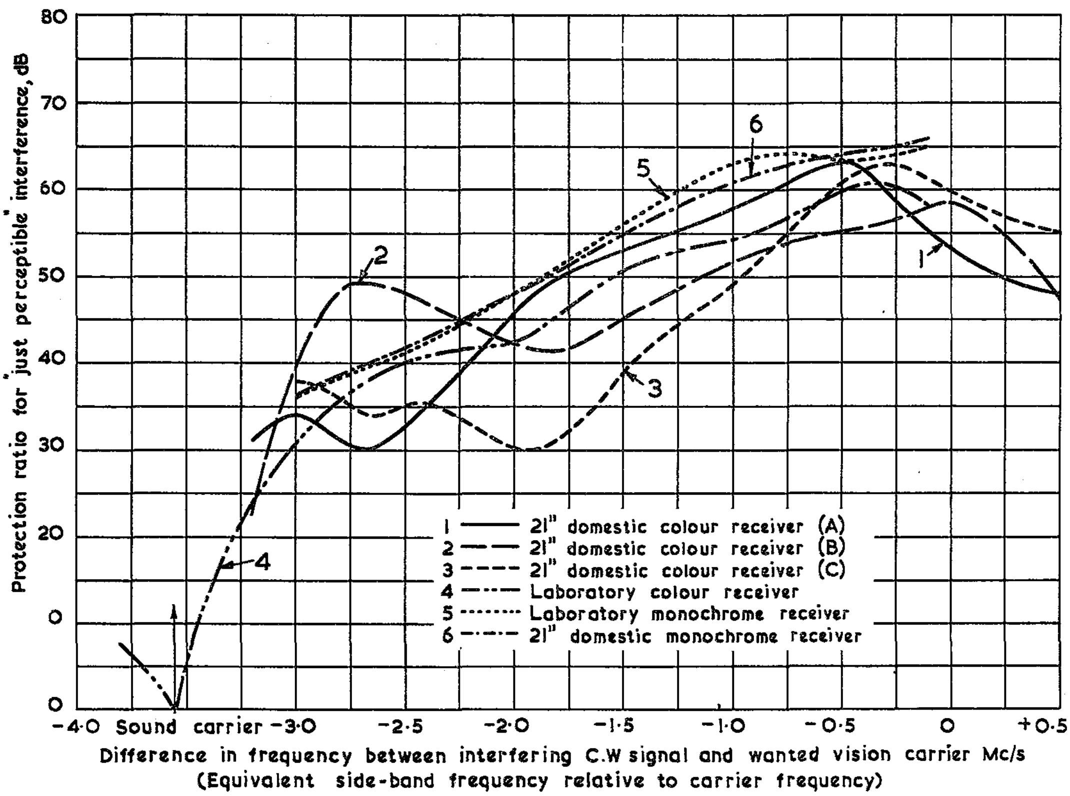

Fig. 2 - Protection ratios for monochrome transmission to colour and monochrome receivers

the requirements for all receivers, although it must be noted that the protection curves appertaining to the colour receivers tend to indicate additional effects when the interfering frequency lies within the chrominance band. All the colour receivers tested were equipped with some form of "colour killer" disabling the chrominance channel in the absence of the colour "burst". An interfering signal within the chrominance band will appear in the post-synchronising suppression interval of the detected video waveform and if this signal is of sufficient amplitude the receiver chrominance channel will become operative and the reproduced picture (which would normally appear in monochrome) will be tinted by "rainbow" stripes. These stripes may differ from conventional interference patterns in that if the local colour reference oscillator becomes locked to the interfering signal the pattern will be stationary and vertical. Locking may well occur by virtue of the sidebands, spaced by line frequency, which are produced by the action of the "burst" gate operating on the interference.

Before proceeding further it is important to observe that these "colour killer" effects, peculiar to the colour receiver, are characterised by a threshold in that, as the interference level is reduced, the spurious colorations remain easily observable until the "killer" operates, whereupon all interference virtually disappears as the remaining high frequency luminance pattern is near or below the "just perceptible" value. The effect exhibits an abrupt threshold due to the action of chrominance

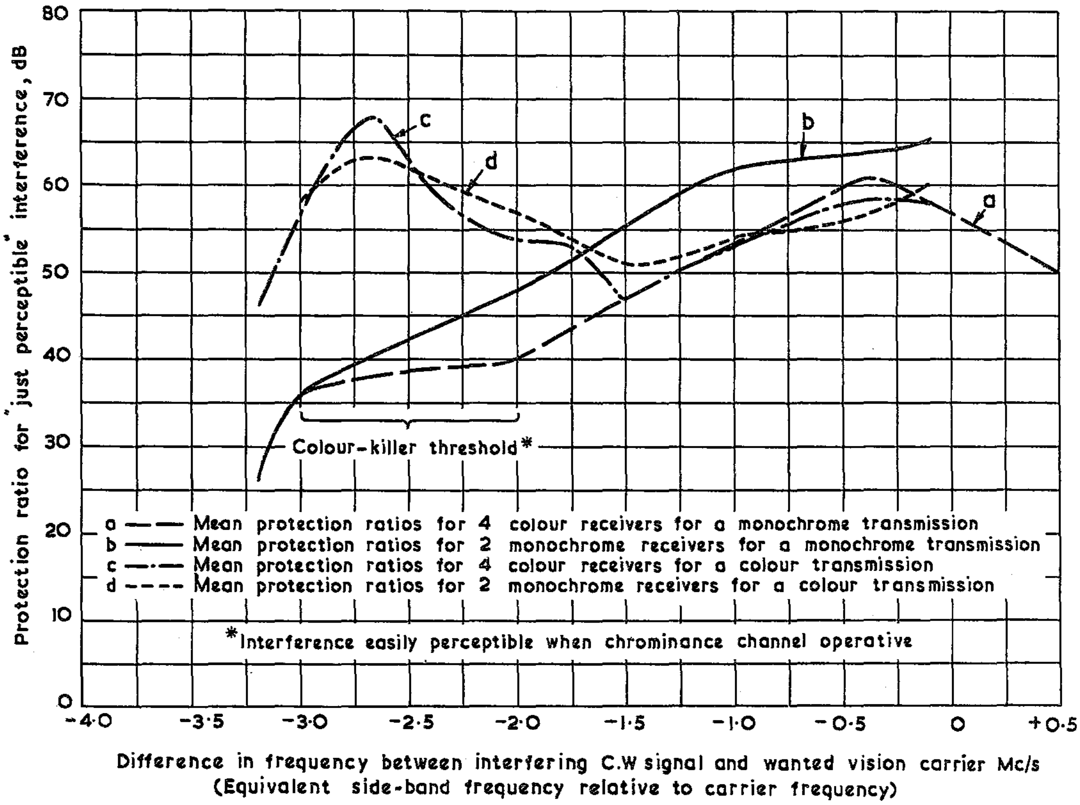

Fig. 3 - Mean protection ratios for various conditions

A.G.C. These factors must be borne in mind when consideration is given to practical protection ratios based on a less stringent criterion than that used in these experiments. The results described must also be of interest to receiver designers considering "colour killer" circuits.

Fig. 3 shows average characteristics taken from Figs. 1 and 2. They include the averages for the four colour receivers when receiving either monochrome or colour transmissions and similar curves are shown for the two monochrome receivers. Examination of curves (c) and (d) shows great similarity between the monochrome and colour receivers with colour transmissions as noted in Fig. 1. Curve (a) shows that the colour receivers require similar protection ratios for both monochrome and colour transmissions except in the vicinity of the chrominance subcarrier. Curve (b) shows that the two monochrome receivers require a somewhat greater protection ratio when receiving monochrome transmissions as compared with colour transmissions, (d), when the interference falls outside the chrominance channel. This is probably because the dot pattern due to the colour transmissions has the effect of masking the interference. These two receivers are also more susceptible to interference than the colour receivers when monochrome signals are being received. This may be due to the lower resolution and contrast range of the colour receiver displays.

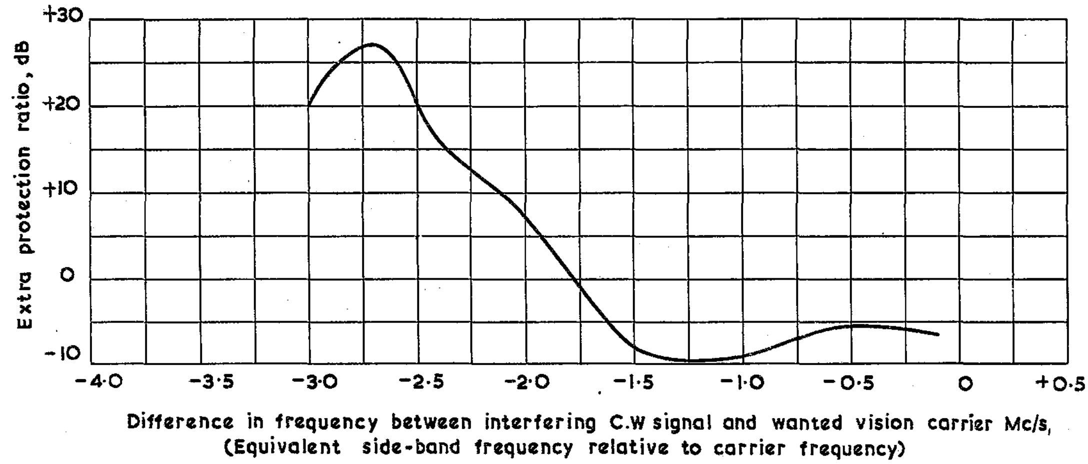

Fig. 4 - Extra protection ratio for colour and monochrome receivers when used to receive a colour transmission as compared with monochrome reception by monochrome receivers

Fig. 4 shows the difference between the average protection ratios required for all six receivers with colour transmissions and those for the two monochrome receivers accepting monochrome transmissions. This curve shows the change of required protection ratio consequent upon the introduction of an N.T.S.C.-type colour television signal in the present monochrome channels. The negative lobe of Fig. 4 illustrates the effect, previously mentioned, whereby monochrome receivers, accepting monochrome transmissions, show a greater susceptibility to interference occurring near to the vision carrier.

4. THE MODIFICATION OF ACCEPTED PROTECTION RATIOS.

The accepted protection ratio characteristic for monochrome service[5] is shown as curve (a) of Fig. 5. This has been obtained in terms of the subjective

criterion "just tolerable for a short percentage of the time (between 1 and 10%)".

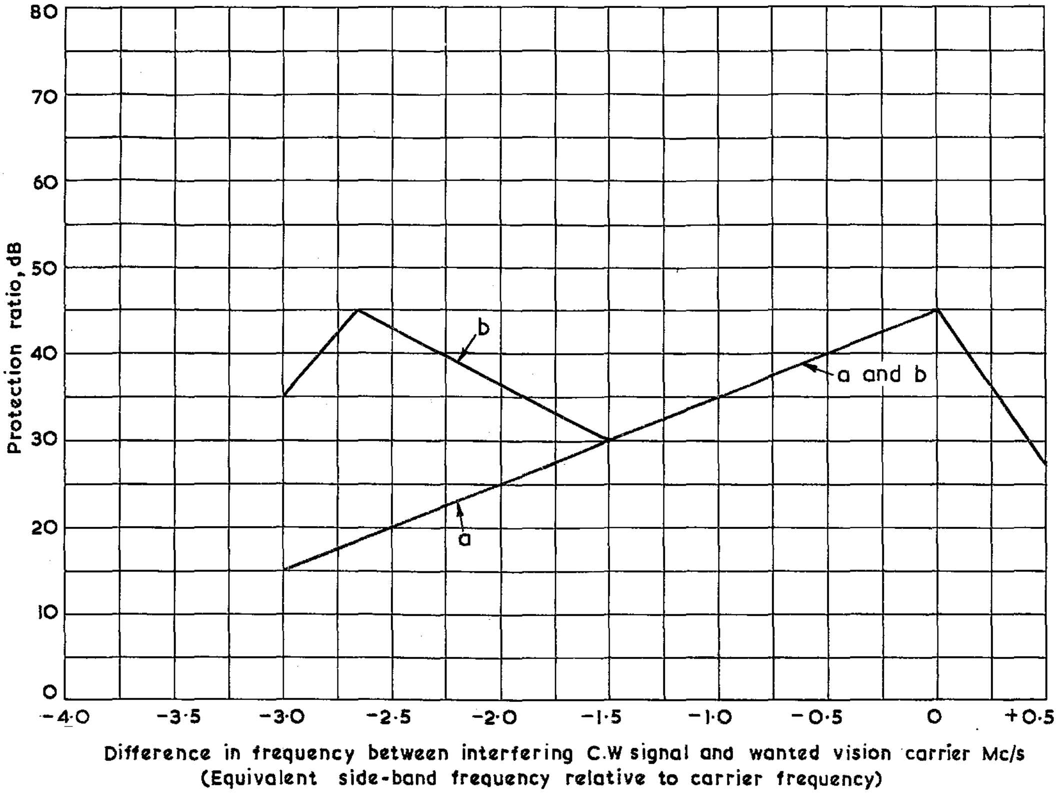

Fig. 5 - Curve (a) Agreed protection ratios for a monochrome receiver receiving a monochrome transmission (Ref. 5)

Curve (b) Protection ratios recommended for:

(i) Colour and monochrome receivers receiving an N.T.S.C.-type colour transmission

(ii) Colour receivers receiving a monochrome transmission

Curve (b) shows the characteristic recommended should either an N.T.S.C.-type colour signal be transmitted or colour receivers be used with a monochrome transmission in the particular channel under consideration. This characteristic has been constructed by the addition in idealised form of the positive lobe of Fig. 4 to curve (a) of Fig. 5. The negative lobe of Fig. 4 has been ignored because to take account of it would result in an unwarranted relaxation of present monochrome standards.

It should be noted that curve (b) is also recommended for use when considering colour receivers operating with monochrome transmissions. "Colour killer" effects were described when discussing Fig. 2 and reference to Fig. 3, curve (a), will reveal the necessity for a 40 dB protection ratio near subcarrier frequency when a colour receiver is operating on a monochrome transmission. This ratio cannot, because of the effect of chrominance A.G.C., be relaxed when applying the results obtained to the less stringent criterion.

It will be seen that the protection ratios of curve (b), Fig. 5, are some 20 dB below those measured. At first sight this may appear to show that a change in

criterion from "just perceptible" to "just tolerable for less than 10% of the time" is represented by this figure. The measurements were carried out, however, under conditions of very good signal-to-noise ratio and it has been shown[2] that protection ratios, for the "just perceptible" criterion, can be relaxed 12 dB for fringe area reception. Furthermore, it is stated[5] that for the "just perceptible" criterion as opposed to "just tolerable" the protection ratios quoted in Fig. 5, curve (a), would be increased 6 to 10 dB.

5. CONCLUSIONS.

Measurements have been made of the increase in protection ratios necessary for an N.T.S.C.-type colour service as compared with the existing monochrome service. It has been shown that the protection ratios must be increased by up to 28 dB for interference in the chrominance band of the wanted signal, a result in agreement with that of Fredendall[1]. Recommended practical protection ratios for a colour service have been derived and reproduced in an idealised form.

6. REFERENCES.

1. G.L. Fredendall, "A Comparison of Monochrome and Color Television with reference to Susceptibility to various types of Interference", R.C.A. Review, Vol XIV, No. 3, September 1953.

2. Post Office Engineering Department Radio Report No. 2112, "The Subjective Effect of Interference between two Television Transmissions".

3. B.B.C. Research Department Report No. T-015, "Investigation into the Possibility of Common Wave Operation of Television Transmitters".

4. B.B.C. Research Department Report No. T-028, "Co-Channel Interference in Television Broadcasting".

5. Report No. 34, C.C.I.R. VIIth Plenary Assembly, London 1953, "Ratio of the Wanted to Unwanted Signal in Television".

MM

Printed by B.B.C. Research Department, Kingswood Warren, Tadworth, Surrey